

Raukūmara Pae Maunga Seedling Ratio Index Monitoring 2024/25

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2.0 INTRODUCTION

This report covers the initial season of Seedling Ratio Index monitoring (SRI) for the Raukūmara Pae Maunga project (RPM), including planning, training, establishment and measurement.

Raukūmara Pae Maunga is a project jointly led by Ngāti Porou and Te Whānau-a-Apanui. Supported by Te Papa Atawhai / Department of Conservation, and others, the project's vision is to restore the mana and mauri of te Raukūmara, so it again thrives, flourishes and nurtures all who are connected to it:

To achieve the ecological and cultural restoration and revitalisation of the Raukūmara

Underpinned by the values of Aroha, Pono and Manaakitanga, the project's objectives include habitat recovery, predator control, ecological and species recovery, and having connected, healthy, strong kaitiaki and communities.

A key component of the restoration work is the management of wild ungulates, particularly red deer (*Cervus elaphus scoticus*), through aerial and ground culling activities. SRI was developed as an affordable and robust monitoring method to assess ungulate impacts in forests and the short-term outcomes of ungulate control. Therefore, SRI is being used as an outcome measure for the aerial- and ground-based deer and goat (*Capra hircus*) management within RPM. The locations of the SRI monitoring sites are shown in Figure 2-1, and the ungulate management areas and monitoring sites are shown in Figure 2-2. (Note: Ungulate Management Areas 5 and 6 have not yet received management and so no outcome monitoring was undertaken in these areas (for example at the Motu Monitoring Site)).

The operational objectives for this work were:

1. To train project kaimahi in the SRI method and plant identification
2. To establish and measure four lines each at six sites (24 in total)
3. To analyse and report on the work



FIGURE 2-1: LOCATION OF SEEDLING RATIO INDEX MONITORING SITES

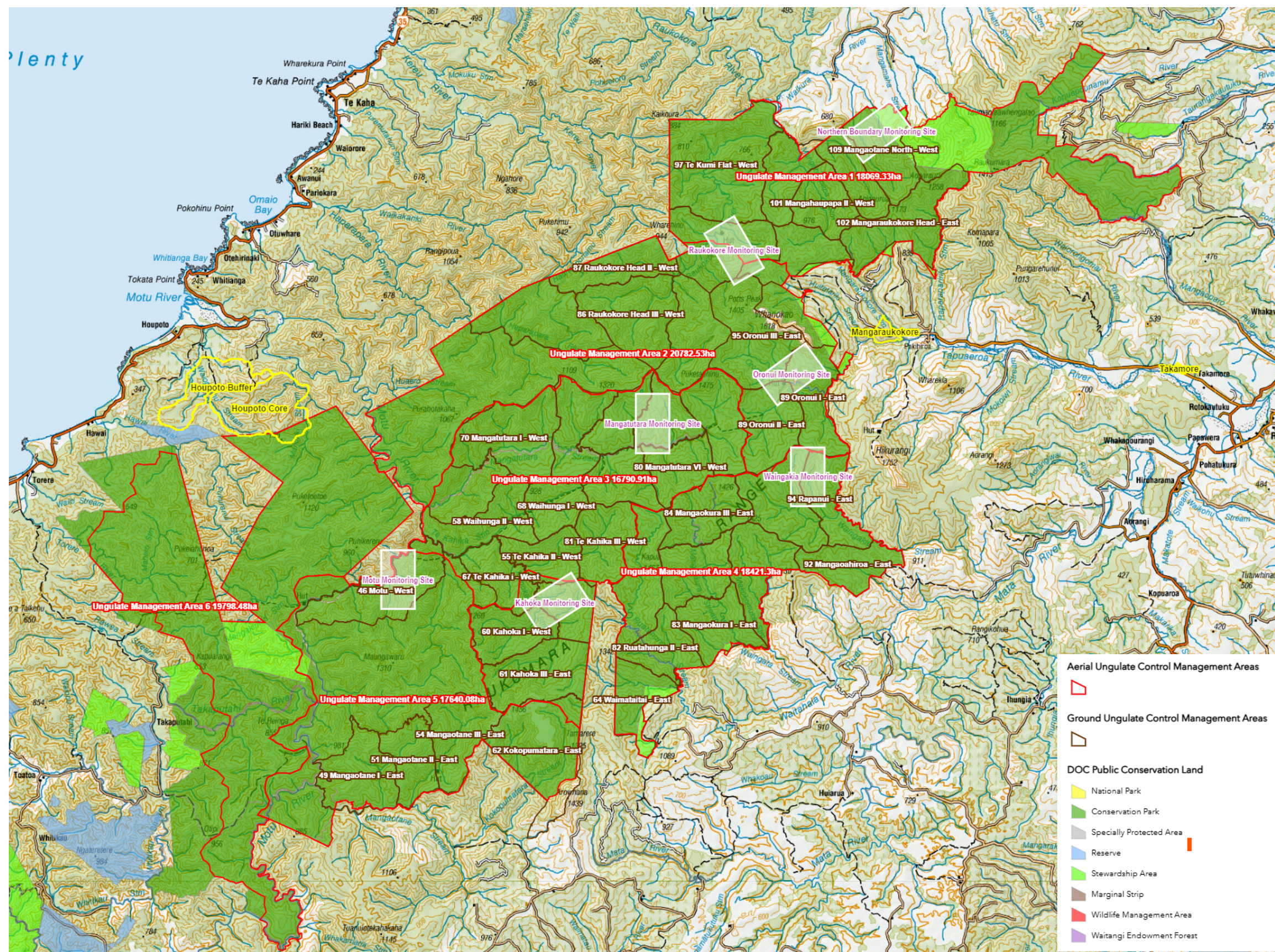


FIGURE 2-2: RAUKŪMARA PAE MAUNGA UNGULATE MANAGEMENT AREAS AND SRI MONITORING SITES

3.0 METHODS

3.1 LINE SELECTION

Transect line start points were selected from a set of 25 randomly-generated points supplied by a DOC technical advisor. Initially, this selection was completed by Roland Pomana and Rob Whitbourne, with four line start points per site chosen, and the start points and lines entered into the RPM Operational Overview dashboard and database. The criteria for selection was safety and feasibility with start points rejected if the terrain appeared too steep or otherwise dangerous, and if the start points were too far from the camp meaning it was unlikely that the line could be completed in one day. As part of the initial selection, a decision was made to use magnetic north as the bearing for all transect lines.

A review of the lines for each site was made by the author in conjunction with the other team members. This process was particularly informed by the experiences gained from completing the first two sites (Oronui and Mangatutara), where both terrain, travel time from camp as well as time completing the line influenced how we considered line selection at the four remaining sites.

The line start point review included looking at aerial photography to assess whether any proposed lines crossed large expanses of gravel, slips, or unsuitable vegetation. Once the line start points had been decided, maps were generated as well as GPX files of the start points for uploading to handheld GPSs.

3.2 TRAINING FOR FIELD WORK

Three sessions held at the RPM Te Kaha office and surrounding area: one each in July, August and October. The goals for the training included:

- Introducing kaimahi to the SRI method
- Practicing the method in the field
- Familiarising kaimahi with the SRI app(s)
- Deepen plant identification knowledge

The field-work components of the sessions were completed at three sites: 1) behind the office; 2) the horse paddock by Haparapara River; and 3) on private land near Te Kaha

Additional plant identification training and provision of resources for project kaimahi was led by Hirere Ngamoki.

Training, especially for plant identification also took place during data collection.

3.3 DATA COLLECTION FORM DEVELOPMENT

Eagle Technology through Roland Pomana was contracted to provide technical services for data collection, storage, analysis and display for the Pae Maunga project, primarily through the ArcGIS® suite of products. Data for all fieldwork in the project is collected using smartphone applications (apps).

For the SRI work, ArcGIS® Survey123 'forms' were developed to collect data. There were two phases of form development; the first phase involved a two-day brainstorming session to develop a form. Ongoing refinement by Roland ultimately resulted in a single form designed to collect all

the required information for a transect line. The DOC SRI protocol field data sheets were used as reference to ensure all critical information was captured.

When using the first form, data collection for the entire transect line was treated as a single event. In other words, the form was opened at the transect line start point, and data collection continued in the same form until the line was finished at which point the form was saved to the app Outbox (ready for upload when in Wi-Fi coverage). Provision was made in the form for collecting data about the start point, the field team (observer and recorder), location information, transect line information, as well as plot data for seedlings, browse and animal presence. If any deviations needed to occur, information about these could also be recorded.

The first iteration of the form was used for the first three sites, Oronui, Mangatutara and Raukokore. However, field staff encountered problems with continuity of data, with some line data being lost, or partially lost. The cause of the data loss was difficult to isolate but may have been related to the large reference table that was required for plant names. This situation was problematic when data was lost for plots that had already been completed and had to be remeasured.

The loss of data (and potential future occurrences) caused concern, and discussions were held to improve the form. Using the model of how data was collected for other Pae Maunga field work, a new approach was made where data would be collected for smaller 'chunks' of work, and completed forms could be saved to the platform's outbox at each physical location where data was gathered.

In the second phase of development, three separate forms were created for collecting data: one each for the start point, plot data, and for deviations (see Sections below for explanations on each of these). For plot data, each individual plot was now recorded separately to any other plot meaning data would be saved before moving physical location. Further, the reference list of plants was much reduced, lessening the risk of data loss.

The second iteration of forms was used for the last three sites, Kahoka, Northern Boundary and Waingakia.

The data collection forms were made available to field workers through the Survey123 app via a RPM project log on.

3.4 FIELD WORK – GENERAL INFORMATION

Field work to measure the 24 transect lines at six sites began on 4 November 2024 and finished on 11 March 2025. There were five field trips with two sites (Oronui and Mangatutara) being completed during the first field trip 4-7 March 2024. Raukokore was completed the following week (12-13 March 2024) while Kahoka, Northern Boundary and Waingakia were completed in February and March 2025 (Table 3-1).

Five of the monitoring locations were the 'permanent monitoring sites', while the Northern Boundary site was a new location. In the project, permanent monitoring sites were established to safely undertake pest animal monitoring associated with aerial 1080 applications in particular. They have basic infrastructure such as campsites, long-drop toilets and marked access tracks as well as monitoring stations. Two of the sites, Oronui and Mangatutara, also have Department of Conservation huts.

The field work was delivered by four field staff, made up of two teams: Heath Hovell and Hirere Ngamoki made up one team, and Iain Grant and Greg Moorcroft made up the second team. Both Hirere and Greg were experienced in vegetation monitoring and were the designated team leads. Hirere, Heath and Iain are all project kaimahi, while Greg (Mamaku Environmental) was contracted in to help with the work.

All except one of the lines were measured in separate teams; MAN20 at Mangatutara was able to be completed by all four field workers.

TABLE 3-1: SRI LINE COMPLETION INFORMATION

Site	Date	App and dashboard line number	Planned (mapped) line number*	Measured by
Oronui	4/11/2024	6	6	Iain and Greg
		19	19	Hirere and Heath
	5/11/2024	13	13	Iain and Greg
		19	3	Hirere and Heath
Mangatutara	6/11/2024	2	2	Hirere and Heath
		8	8	Hirere and Heath
		21	21	Iain and Greg
	7/11/2024	20	20	All
Raukokore	12/11/2024	16	12	Hirere and Heath
		24	23	Iain and Greg
	13/11/2024	1	17	Hirere and Heath
		9	10	Iain and Greg
Kahoka	23/01/2025	1	1	Iain and Greg
		7	23	Hirere and Heath
		15	4	Hirere and Heath
	24/01/2025	2	2	Iain and Greg
Northern Boundary	3/03/2025	2	1	Iain and Greg
		24	22	Hirere and Heath
	4/03/2025	11	7	Iain and Greg
		12	12	Hirere and Heath
Waingakia	10/03/2025	6	14	Hirere and Heath
		24	24	Iain and Greg
	11/03/2025	7	7	Iain and Greg
		21	22	Hirere and Heath

*Note: the 'Planned (mapped) line number' was chosen after a second line start point selection process and differs from the 'App and dashboard line number' where some initially selected start points were deemed unsuitable. However, the app was not updated for all the start point changes therefore the line numbers listed in the 'App and dashboard line number' are considered the key reference numbers.

At some sites, other work was able to be completed as part of the trip. At Waingakia, Micheala Insley from the project's communications team joined the team in the field to learn about the process and capture footage. Also in the field for the Waingakia trip was Mikaere Albert, whose primary task was to deliver rat tracking index monitoring but did accompany Iaian and Greg to help measure line WAI24.

The Northern Boundary site was entirely new, with no existing infrastructure. Here, managers are investigating whether the presence of unmanaged deer on nearby farmland could result in poorer recovery of palatable seedling than at other sites where deer are managed (due to higher re-invasion pressure).

Field work was organised by the Operations team field supervisors and team leads, including timing, transport (helicopter) and provisioning (food and equipment).

All sites were accessed via helicopter, with two operators servicing the project, both based near Ōpōtiki: Motu Helicopters (Steve Woods) and Kahu NZ (Luke Lamont). Greg was able to fly from the helicopter bases near Ōpōtiki, while Hirere was picked up near Te Kaha and Heath and Iaian were picked up near Ruatōria or at Pakihiroa Station. The flying order was reversed when field trips were completed.

Generally, field staff were flown to a camp site from which SRI lines were accessed. Staff returned to the camp site and were extracted from the field from the camp site when the work was completed. During the first field trip, teams were moved from Oronui to Mangatutara via helicopter on the third day of five. The Waingakia trip was done over three days/2 nights, while the other three sites were completed over 2 days / 1 night.

3.5 FIELD WORK – COLLECTING DATA

The process for collecting SRI data has now been captured in a separate document, Raukūmara Pae Maunga Seedling Ratio Index Field Protocol (in draft), which gives detailed information on how to measure SRI lines. However, a summary of the process is given below.

1. Each field team was allocated two transects to measure per site.
2. Line start points were navigated to using a hand-held GPS with pre-loaded waypoints. The route to get the start point was decided by the field workers and existing tracks were used as much as possible.
3. Once at the start point, the nearest suitable tree within 50 metres was selected and marked using pink plastic markers. Information about the start point, including location, was captured into field forms: either the 'whole line' form used for the first three sites, or the dedicated 'start point' form used in the final three sites.
4. From the start point, a transect line based on magnetic north (zero degrees magnetic) was followed using a handheld compass. Distance along the transect line was measured using a five-metre running line and direction was direction set using a hand-held compass set to the magnetic bearing. For RPM SRI work, the transect bearing was always magnetic north (= 0° magnetic) to begin with
5. Along the transect bearing, the first plot was measured 20 metres from the start point. Subsequent plots were measured every 20 metres from the previous one
6. The intention was to measure 20 plots per transect line
7. Data was collected on the plot using ArcGIS® Survey123 forms: either the 'whole line' form used for the first three sites, or the dedicated 'SRI and Pellet' form used in the final three sites. On the plot, data was collected for the following categories:

- a. General plot information
 - b. Short and tall seedlings
 - c. Browse
 - d. Animal presence
8. A string fixed on a peg with knots at 0.49 cm and 1.41 cm and a tape measure, was used to measure plots
 9. 'Short seedlings' were those found rooted within a circle of radius 49 centimetres that were less than 30 centimetres in height
 10. 'Tall seedlings' were those rooted in a circle of radius 1.41 metres and were from 30 centimetres to two metres in height
 11. 'Browse' was any recent ungulate browse on target species found within a 'cylinder of interest' 1.41 metres in diameter, from 15 centimetres to two metres above the ground. Browse was scored from 0 (= no browse) to 4 (76% to 100% browse)
 12. The animal sign recorded was:
 - a. Presence (Yes / No) of *intact* ungulate (deer or goat) pellets
 - b. Presence (Yes / No) of *non-intact* ungulate (deer or goat) pellets
 - c. Presence (Yes / No) of possum faecal pellets
 - d. Presence (Yes / No) of pig dung
 - e. Presence (Yes / No) of pig rooting
 13. Along the transect, a 'deviation' to 90 degrees to the west or to the east could occur if travel on the original bearing was unsafe. Information about the deviation recorded on a specific Survey123 form ('SRI Transect Deviation'). Further deviations could occur as long as the line bearing did not turn back towards the start point
 14. Transects were deemed completed:
 - a. After the 20th plot had been completed; or
 - b. It was unsafe to continue (including after deviations); or
 - c. There was not enough time to complete the transect

3.6 TARGET PLANTS FOR MONITORING

For the first three sites (Oronui, Mangatutara and Raukokore), the plant list for the DOC protocol was used when recording seedlings and browse in the plots. The DOC protocol categories were based on the growth form classification in the National Vegetation Survey database. Plants included were those classified as: Tree, Shrub, Palm (nikau), Grass tree (Cordyline and Freycinetia), Tree ferns, Ferns and 'WoodyMixed' plants. The plants that were excluded were: vines, grasses, herbaceous flowering plants, and non-vascular species. Based on the list downloaded on 21 October 2024, 1,305 species were potentially available, although not all of these are present in the Raukūmara.

A date-stamped NVS plant list was downloaded from the Manaaki Whenua / Landcare website and uploaded into the recording app. Vernacular plant names with macrons proved to be problematic as the letters with macrons were replaced by question marks during the download and when uploaded into the app those species could not be searched in the app search box. This problem was solved by requesting a special copy of the list which included letters with macrons. As it appeared the app software did not accept the macrons, even from this list, all letters with macrons were replaced by the same letter without a macron

As above, the DOC protocol target list of plants was used for the first three sites (Oronui, Mangatutara and Raukokore); however, a proposal by the Deer and Goat Manager, George Cooper, resulted in a process whereby a list of 23 plants were selected and loaded into the app for use at Kahoka, Northern Boundary and Waingakia. The RPM list of target plant species is shown in Table 3-2.

TABLE 3-2: LIST OF PLANTS USED IN SRI MONITORING

RPM name	Te Reo	Common name	NVS Code	Preferred Code	Palatability
Makomako		Wineberry	ARISER	ARISER	Preferred
Pikopiko		Hen and chickens fern	ASPBUL	ASPBUL	Not selected
Tawa		Tawa	BEITAW	BEITAW	Avoided
Putaputaweta		Marbleleaf	CARSER	CARSER	Not selected
Kanono		Kanono	COPGRA	COPGRA	Preferred
Karamu		Shining karamu	COPLUC	COPLUC	Preferred
Karamu		Karamu	COPROB	COPROB	Unclassified
Karamu		Wavy-leaved coprosma	COPTEF	COPTEF	Preferred
Kiekie		Kiekie	FREBAN	FREBAN	Unclassified
Kotukutuku		Tree fuchsia	FUCEXC	FUCEXC	Preferred
Hangehange		Hangehange	GENLIG	GENLIG	Preferred
Kapuka		Broadleaf	GRILIT	GRILIT	Preferred
Tawari		Tawari	IXEBRE	IXEBRE	Unclassified
Mahoe		Mahoe	MELRAM	MELRAM	Preferred
Mapou		Red matipo	MYRAUS	MYRAUS	Preferred
Tawai		Red beech	NOTFUS	FUSFUS	Avoided
Tawai		Hard beech	NOTTRU	FUSTRU	Unclassified
Kohuhu		Black matipo	PITTEN	PITTEN	Unclassified
Totara		Hall's totara; mountain totara	PODHAL	PODLAE	Avoided
Totara		Totara	PODTOT	PODTOT	Unclassified
Whauwhaupaku		Five-finger	PSEARB	PSEARB	Preferred
Pate		Seven-finger	SCHDIG	SCHDIG	Preferred
Kamahi		Kamahi	WEIRAC	PTERAC	Preferred

3.7 DATA ANALYSIS

Each transect line was treated as a sampling unit. A seedling ratio index was calculated for each line using the following formula where the 'talls' and 'shorts' refer to the two seedling classes of the data collected. Appendix 9.1 contains the calculated SRI for each line.

$$\text{SRI} = \frac{(\text{number of talls} - \text{number of shorts})}{(\text{number of talls} + \text{number of shorts})}$$

Analysis of the data collected is based on the palatability classes that are listed in the National Vegetation Survey database. These classes are based on a publication (Forsyth et al., 2002) where the level of plant palatability to ungulates has been categorised as either: Avoided, Preferred, Not selected, Unclassified. The palatability groups for the RPM list of 23 plants is shown in Table 3-3.

For each palatability class, the mean (average) SRI for each line was calculated. Further analysis was done by calculating the mean SRI for each palatability class for each site, and where appropriate, 95% confidence intervals.

TABLE 3-3: TARGET PLANTS CLASSIFIED BY PALATABILITY TO DEER

Palatability	RPM name	Te Reo	Common name	NVS Code	Preferred Code
Preferred (12 species)	Makomako		Wineberry	ARISER	ARISER
	Kanono		Kanono	COPGRA	COPGRA
	Karamu		Shining karamu	COPLUC	COPLUC
	Karamu		Wavy-leaved coprosma	COPTEF	COPTEF
	Kotukutuku		Tree fuchsia	FUCEXC	FUCEXC
	Hangehange		Hangehange	GENLIG	GENLIG
	Kapuka		Broadleaf	GRILIT	GRILIT
	Mahoe		Mahoe	MELRAM	MELRAM
	Mapou		Red matipo	MYRAUS	MYRAUS
	Whauwhaupaku		Five-finger	PSEARB	PSEARB
	Pate		Seven-finger	SCHDIG	SCHDIG
	Kamahi		Kamahi	WEIRAC	PTERAC
Not selected (2 species)	Pikopiko		Hen and chickens fern	ASPBUL	ASPBUL
	Putaputaweta		Marbleleaf	CARSER	CARSER
Unclassified (6 species)	Karamu		Karamu	COPROB	COPROB
	Kiekie		Kiekie	FREBAN	FREBAN
	Tawari		Tawari	IXEBRE	IXEBRE
	Tawai		Hard beech	NOTTRU	FUSTRU
	Kohuhu		Black matipo	PITTEN	PITTEN
	Totara		Totara	PODTOT	PODTOT
Avoided (3 species)	Tawa		Tawa	BEITAW	BEITAW
	Tawai		Red beech	NOTFUS	FUSFUS
	Totara		Hall's totara; mountain totara	PODHAL	PODLAE

3.8 LOGISTICS AND PLANNING

Field work was planned and organised primarily by the Operations team supervisors with support from the field team leaders.

Where possible, synergies with other field work were achieved, especially for helicopter transport; for example, working in with the aerial ungulate programme where possible.

Where practical, other tasks were also completed during the field work.

One attempt to fly into Waingakia was aborted due to poor weather conditions (although most of the team were able to complete other field work).

Modern communications technology was used in the field, including the use of Garmin inReach® and Starlink which both use satellite connectivity to provide backcountry communication capability.

4.0 RESULTS

4.1 SEEDLING RATIO INDICES

Over the six sites, 480 plots were measured on 24 lines. Each line is considered a sampling unit so analyses for seedling ratio indices are based at the line-level. Any analysis for a site therefore is comprised of up to four sampling points.

As described in Section 3.5, the target plants are divided into four classifications based on their palatability to deer: Preferred (12 plants), Avoided (3), Not selected (2) and Unclassified (6). However, of the 23 plants targeted for monitoring, two were not recorded during the surveys: whauwhaupaku (five-finger; *Pseudopanax arboreus*; PSEARB; palatability = Preferred) and Kohuhu (black matipo; *Pittosporum tenuifolium*; PITTEN; palatability = Unclassified). This meant the list for Preferred dropped to 11 plants and the list for Unclassified dropped to 5 plant species.

The Seedling Ratio Index for each line was calculated, and then average (mean) values were calculated for sites and also for the four palatability classifications. For any calculations where Seedling Ratio Indices were not able to be calculated, that is, when there were no shorts **and** no tall, the sampling point was removed. For Line WAI21 at Waingakia, no short or tall seedlings of the target plants were recorded, so no Seedling Ratio Index was able to be calculated for this line.

Figure 4-1 shows the mean Seedling Ratio Index for each site with no sub-classifications based on palatability. Here the indices are all negative, however, when the palatability of plants is taken into account, the results show clear trends: Avoided plants had positive SRIs at all sites while Preferred and Not selected plants all had negative indices (Figure 4-2). When the SRIs classified by palatability are aggregated across all sites (Figure 4-3), the difference between the classifications is clear. Figure 4-4 further accentuates this trend but shows the variability between the sites. For Avoided, Not selected and Preferred plant species, there is strong consistency between sites.

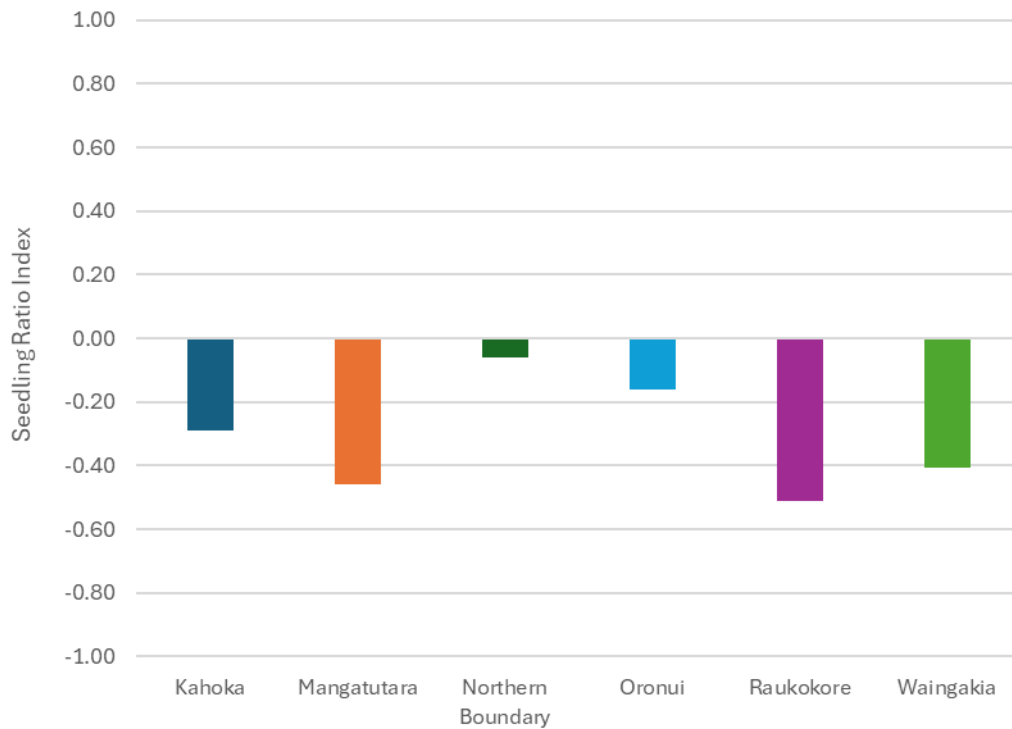


FIGURE 4-1: MEAN SEEDLING RATIO INDEX BY SITE WITH NO SUB-CLASSIFICATION

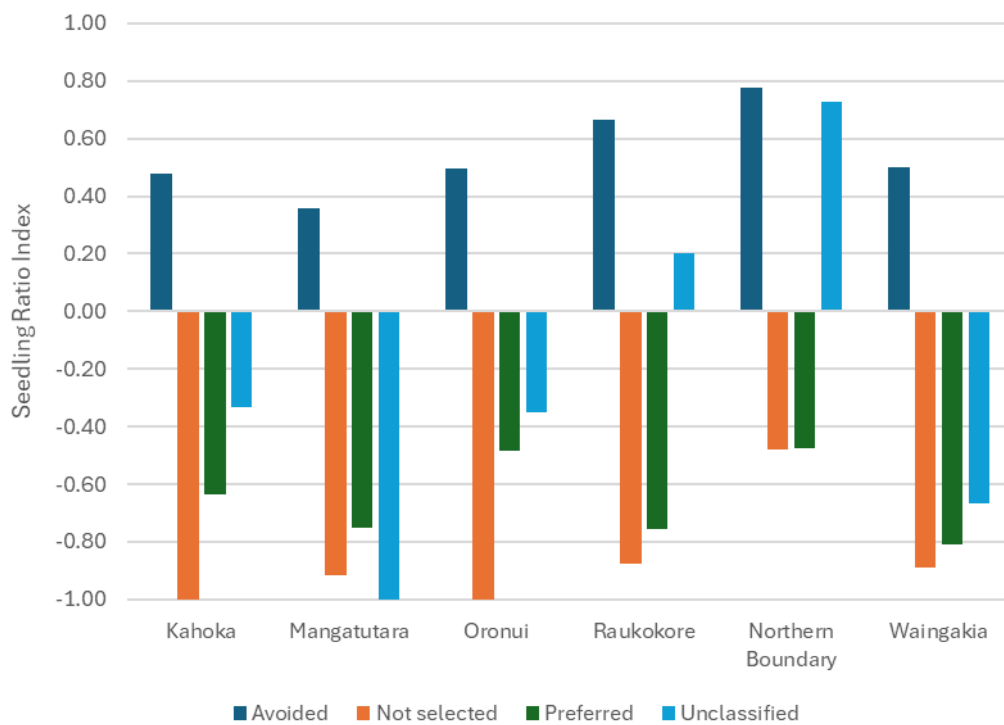


FIGURE 4-2: MEAN SEEDLING RATIO INDICES PER SITE FOR EACH PALATABILITY CLASSIFICATION

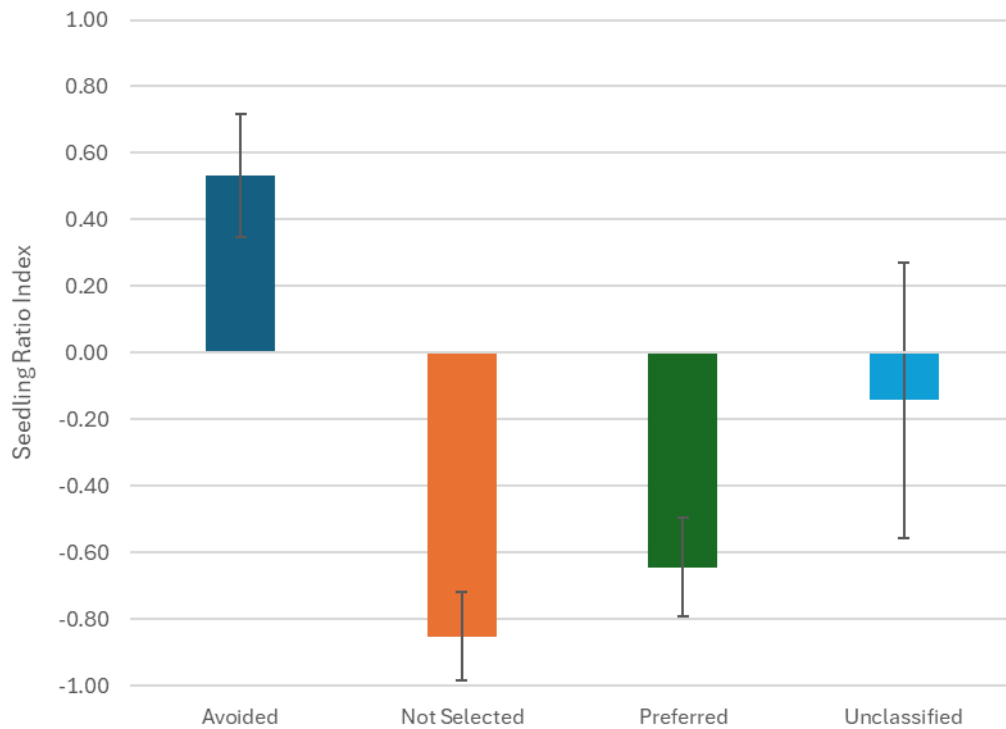


FIGURE 4-3: MEAN SEEDLING RATIO INDEX BY PALATABILITY CLASSIFICATION FOR ALL SITES. ERROR BARS 95% CONFIDENCE INTERVALS

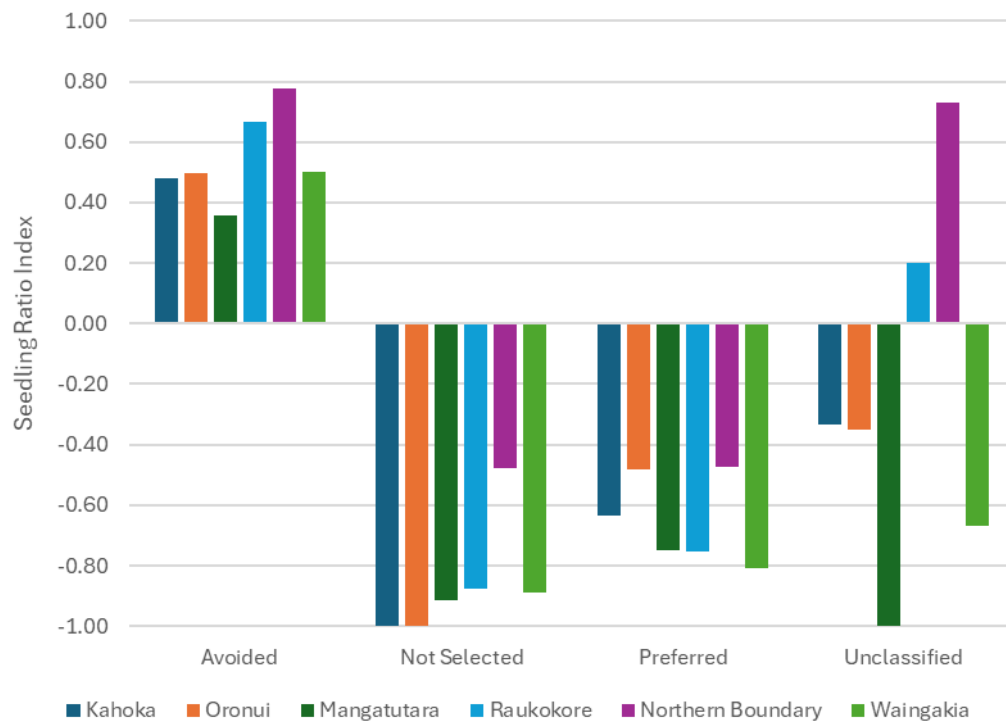


FIGURE 4-4: MEAN SEEDLING RATIO INDICES PER PALATABILITY CLASSIFICATIONS FOR EACH SITE

4.2 BROWSE

Table 4-1 shows the number of target plants that were scored for recent ungulate browse at each of the sites. Across all the plots, 501 target plants were scored with the vast majority (92%) having no browse (score = 0). There were only two instances (0.4%) where target plants were scored as a '4'.

TABLE 4-1: NUMBER OF TARGET PLANTS SCORED AT EACH AT EACH BROWSE LEVEL (0 = NO BROWSE; 1 = 1% - 25% BROWSE; 2 = 26% - 50% BROWSE; 3 = 51% - 75% BROWSE; 4 = 76% - 100% BROWSE)

Site	Browse score = 0	Browse score = 1	Browse score = 2	Browse score = 3	Browse score = 4	Total
Kahoka	62	2	2	3		69
Mangatutara	81					81
Northern Boundary	97	11	1	2	1	112
Oronui	147	4	2	2		155
Raukokore	52	3	3		1	59
Waingakia	24	1				25
Total	461	21	8	7	2	501

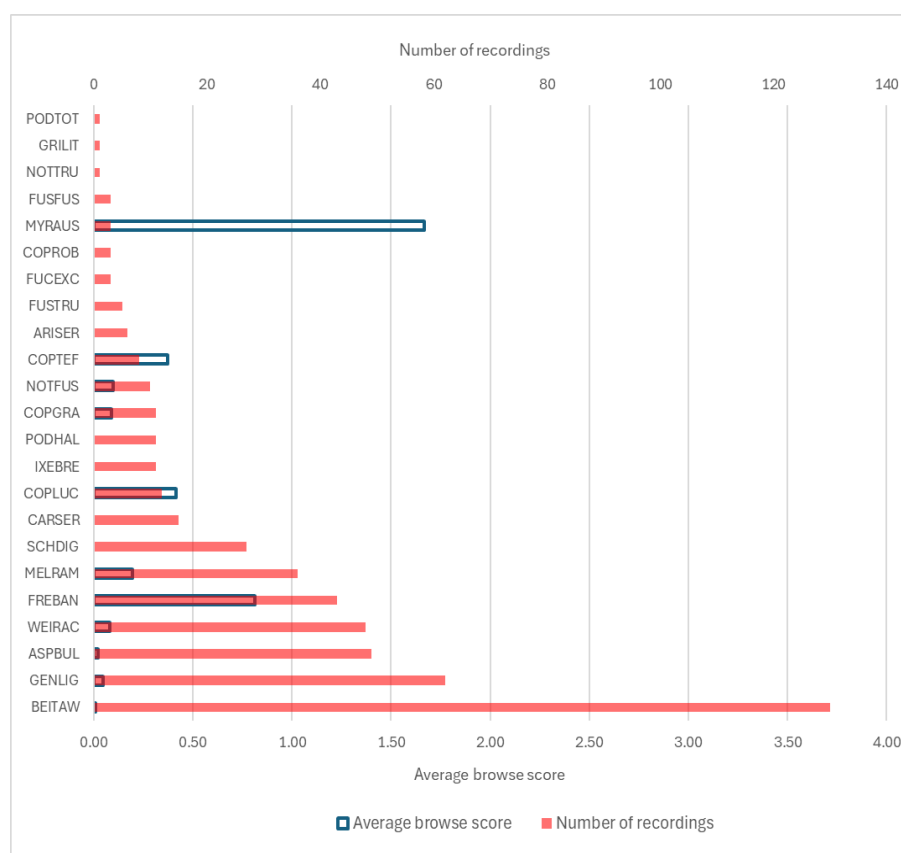


FIGURE 4-5: THE NUMBER OF RECORDINGS AND AVERAGE BROWSE SCORE PER SPECIES FOR TARGET PLANTS ACROSS ALL PALATABILITY CLASSES. (THE SIX-DIGIT CODES REPRESENT THE TARGET PLANTS; SEE SECTION 4.5 FOR MORE DETAIL)

Figure 4-5 shows the list of target plants given by their 6-digit 'code' (see Section 4.5 for more details). The most commonly scored plant was tawa (BEITAW) with 130 recordings, while hangehange (GENLIG), pikopiko (ASPBUL), kamahi (WEIRAC), kiekie (FREBAN) and pate (SCHDIG) were all recorded over 30 times. For browse impact, the highest average for a species was 1.67 for mapou (MYRAUS) although there were only three recordings for this species. Of the most commonly-recorded species (listed above), all averaged less than 1.00 for average browse score.

Figure 4-6 shows the mean browse score by plant species palatability classification. The preferred and unclassified species had significantly more browse than the avoided and not selected species.

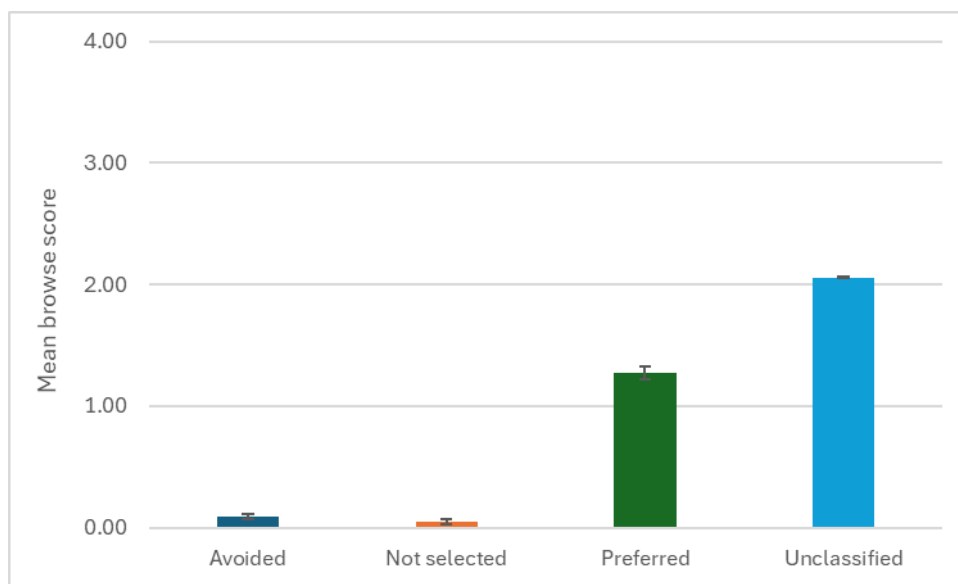


FIGURE 4-6: MEAN BROWSE SCORE BY PALATABILITY CLASSIFICATION. ERROR BARS INDICATE 95% CONFIDENCE INTERVALS

4.3 PEST ANIMAL PRESENCE

Table 5-2 shows a simple proportional calculation for the recorded animal sign across the six monitoring sites. The vast majority of plots had no sign, while 'intact ungulate pellets' were the most encountered animal sign within plots.

TABLE 5-2: NUMBER OF PLOTS PER SITE SHOWING PEST ANIMAL PRESENCE

Site	Intact ungulate pellets	Non-intact ungulate pellets	Possum pellets	Pig dung	Pig rooting
Kahoka	3	3	3	3	3
Northern Boundary	2	2	2	2	2
Waingakia	6	6	6	6	6
Mangatutara	2	1	0	0	4
Oronui	7	4	0	0	0
Raukokore	3	2	0	0	0
Total for all sites	23	18	11	11	15
Total number of plots	480	480	480	480	480
Percentage of plots with animal sign	5%	4%	2%	2%	3%

5.0 DISCUSSION

5.1 MONITORING RESULTS

5.1.1 SEEDLING RATIO INDEX

This is the first measurement of the Seedling Ratio Index (SRI) lines in the project and the results appear to reinforce many anecdotal observations of the state of the understorey in the Raukūmara, in that the number of seedlings in the browse tier (i.e. up to 2 m) is very depleted. This is especially apparent in the data when the palatability to ungulates (primarily deer in this case) of the target plant species is considered. In other words, the results are consistent with what many people see, but reinforces the need to support observational information with quantitative methods that can be reliably repeated so that results can be interpreted with confidence, management decisions can be informed, and ultimately ecological restoration goals can be achieved

It is important to note, that the SRI method is not intended to be a measure of diversity or abundance. Rather, it is intended to be a method that measures the impact of ungulate (deer) management in a particular way. The method works under the well-tested premise that by

reducing deer pressure to low levels there should (eventually) be increased recruitment of seedlings in the browse tier. Other outcome monitoring methods are required to gauge overall forest health. However, for managers, the ever-present question is “how much management is enough?” and perhaps the answer to this question could be found by analysing all relevant data including deer kills per effort and various deer abundance measurements, as well as outcome monitoring results (e.g., SRI).

At this stage, no analysis has been completed on individual plant species, although this could be an done after future measurements, especially for palatable species.

5.1.2 BROWSE

The higher browse score seen for the palatable species was expected especially when compared to the avoided species. Over time, if ungulate management effort is maintained, it is expected that the browse scores for all palatability classes would be very low.

5.1.3 ANIMAL PRESENCE

This method of recording animal presence was added as a very quick way of obtaining some data across the wider management area. As yet, it is uncertain whether this data could be useful, however, it could, over time, with repeated measurements, add to the picture of pest animal abundance and help managers gain insights into the effects of management.

5.2 TRAINING AND LEARNING

Feedback from participants, supervisors, managers and others was that the pre-delivery training sessions went well and prepared the kaimahi well for the field work. The training sites were well chosen and the balance of field time and office time discussing the method seemed to be appropriate.

Excellent support was provided by the Department of Conservation staff, especially Dean Clarke, who gave good advice around how to interpret the DOC protocol, and for RPM to establish its own way of doing things.

Training also continued through the delivery of the field work, especially regarding the learning of plant species. The repetitive nature of SRI monitoring meant that the method was quickly learnt, and improvements could be made as we progressed. It was important to acknowledge the different learning styles of the team and find the best ways to share knowledge. As always, this kind of work is a team affair, all in the field team agreed that there was excellent Manaakitanga respect and consideration between the us all.

5.3 LINE SELECTION

The line selection process generally reflected the challenges of undertaking fieldwork in the Raukūmara especially regarding the design of monitoring programmes. Reducing bias is one of the key principles for sampling work particularly through the use of random selection of sites (for example, SRI transect line start points). However, steep terrain and limited access severely reduce the number of places where monitoring can safely occur and be completed within reasonable time frames. Ultimately, as start points needed to be vetted for safety and achievability, this resulted in a degree of bias being introduced into the site selection; however, the start points used were still drawn from the initial list (provided by DOC) of randomly-generated ones.

As there were only twenty-five start points per site, after points where transects were deemed unsafe or too far were rejected, the number of options for viable transects at each site was much

reduced. The decision to stay with a single initial transect bearing of magnetic north added to the challenge of selecting viable transects. One piece of feedback was that we could have used other (randomly generated) bearings to bring in more start points that were otherwise rejected.

Ultimately, it is important to have network of lines that can be sustainably measured in the future.

5.4 APP DEVELOPMENT

The process to develop an electronic means to capture field data was a good example of adaptive learning. The initial form developed for the ArcGIS® Survey123 form was thought to be fit-for-purpose, even after a degree of testing prior to the field work. However, when put to the test during the field work, the loss of data problems that arose pushed the team into a finding a new solution. When used for second three sites, the suite of three forms, with plot data now being saved per individual plot instead of a whole line, no further problems were reported. RPM now has a fit-for-purpose tool that could be used (probably with adaptations) by other parties.

It remains a critical part of the data process and operational discipline that all electronic data must be uploaded to the project server as soon as possible.

The availability of Wi-Fi connectivity through the Starlink system certainly helped with discussing the initial concerns of managers and Roland Pomona (GIS technical support) with the SRI app encountered at the Oronui site. For other sites, when available, the Starlink Wi-Fi enabled uploading of field data at camp, meaning there was less risk that data could be lost.

5.5 FIELD WORK

The field work relied on having reasonably fit, but suitably experienced kaimahi and this is a strong consideration for future delivery. The first two sites were done back-to-back, and while this took advantage of a weather window and was efficient regarding helicopter use, it proved to be physically taxing on the field staff. Further, the third site (Raukokore) was delivered the following week meaning fatigue accumulated further. Scheduling one site per week is recommended for further monitoring as a starting point as this allows for more flexibility regarding suitable weather and other scheduling pressures, as well as allowing for kaimahi well-being and fatigue levels.

For the sake of good data, it is important that at least one of the people measuring a line (if there are more than one), be confident in identifying the target plants. The reduction of the target plant list has helped the potential for kaimahi less experienced with plant identification to improve their abilities.

Having two people measure a line is probably preferred, at the least for health and safety reasons; however, a line could quite feasibly be measured by a suitably-experienced and capable individual.

A significant consideration for this type of monitoring, especially when establishing transect lines, is having a good process for and allowing enough time to deal with contingencies, particularly if a transect start point needs to be rejected and another one measured. The implication is, that more field time may be needed or less data may be collected. As always, good communication with supervisors and managers and between the field staff is important, as is good planning to allow for these situations.

As this was the first time these lines were measured, there were uncertainties about how long getting to and from the transect lines would take, and which would be the best routes. Overall, this part of the work went quite well. Where possible, the existing access tracks at the permanent

monitoring sites were used and often provided direct or nearly direct access to the start points. Where new routes were required, local knowledge was used as much as possible, and care was taken to find a safe and reasonably direct route of travel. Access to a few of the lines was reviewed and future monitoring visits should take this information into account.

The camp sites used were generally adequate. The huts were used at Oronui and Mangatutara, and the existing camp sites were used at Raukokore and Kahoka. Raukokore has a long drop, as do the hut sites, but the other three sites do not. Northern Boundary was a new site, but an excellent campsite was located next to a small stream just off the main stream where the helicopter could land. The lines were easily accessed from this campsite. At Waingakia, we were dropped at the lower helipad and walked up to the main ridge to a suitable campsite. If there is suitable weather, future monitoring could be done by accessing to the top helipad site and camping nearby (for example, the start of RTI line 5), although water would need to be taken in.

At the outset of the monitoring, it was unclear whether how many could be completed in one day. Planning allowed for one line per day, however, on at Mangatutara and Kahoka Hirere and Heath completed two lines on the first day. It is prudent that planning for future monitoring should allow for one line to be completed per day.

The opportunity for all four field kaimahi to measure line MAN20 at once provided an excellent chance to align our interpretation of the protocol, especially for the more subtle elements such as deciding which plants are considered in the browse tier and how to treat dead logs within the plot.

5.6 APPROACH FOR RPM

It is important to acknowledge that delivering this type of work within this project has challenges because of the weather, terrain and access requirements. However, the approach of the two iwi is to always put the people first: as Sharon Wharepapa put it: “this is more than just transactional monitoring”. Building capability, delivering field work to a high standard, keeping safe both physically and culturally are all elements that need to be balanced but the emphasis is always on the kaimahi.

From the outset, the intention was to use a DOC protocol as a starting point to build an RPM monitoring approach that was fit-for-purpose. The development of app was part of the ongoing innovative approach within the project for data collection, and the reduction of the plant list was seen as a pragmatic way to more easily allow kaimahi to learn the required plants and deliver work without outside help.

As discussed above, the process for line selection also reflected the needs of the project.

5.7 LOGISTICS AND PLANNING

It took significant effort to plan, organise and support the field work, with the burden for this primarily falling on the operations team supervisors, Sharon Wharepapa and David Morice. Helicopter support, in particular, required detailed planning, and when plans changed, helicopter schedules and flight plans also had to be adjusted.

As mentioned elsewhere, the use of the Starlink to provide Wi-Fi at camp added very useful communication capability, especially for rearranging travel and also uploading data. There were added requirements as a generator was needed to power the Starlink and as this required petrol, managing this as a dangerous good had to be considered.

Generally, managing helicopter flights, especially the quantity of equipment taken, was an ongoing consideration and learning experience.

5.8 HEALTH AND SAFETY

There were no significant health and safety incidents or concerns during the field work. Good practices were followed throughout the field season including carrying the correct equipment, doing toolbox talks and debriefing field trips. Field kaimahi always erred on the side of caution when assessing risks: as Hirere put it, “we don’t die for data”.

5.9 FUTURE WORK

As the SRI is part of an outcome monitoring regime, it is expected that the transect lines will be re-measured a number of times. There are several factors that need to be considered when deciding how frequently lines are measured:

1. Use of resources: although a *relatively* quick method, SRI monitoring still demands significant resources, including staff time and operating expenditure, mainly in the form of helicopter hire.
2. Opportunity cost: As with all activities, if resources are spent on SRI monitoring, some other activity or activities won’t be done
3. Impact on lines: if lines are measured frequently, for example, annually or biennially, it is likely that there will be impact from walking on the plot areas, possibly influencing the sampling
4. Rate of change: plants tend to grow slowly under the forest canopy, so it is likely that measurable change will take several years to happen
5. Not missing change: in contrast to point 4, if monitoring was done too infrequently, the opportunity to learn about the impacts of the ungulate management regime may be missed

The suggested re-measure period for SRI lines is three years (Oliver Gansell, pers. comm.), and it is recommended that a re-measure be done no less than this period, that is, no later than 2027/28.

To obtain comparable data, it will be important to maintain consistency in methodology, so it is recommended that the Raukūmara Pae Maunga Seedling Ratio Index Field Protocol be followed when measuring SRI lines. It follows that field staff will need to be suitably experienced in plant identification (as well as being suitably fit and capable for backcountry fieldwork). Consideration can be given to maintaining and growing capability (plant identification; app use; SRI method) by undertaking SRI monitoring at a front country site where fewer resources need to be committed. This could happen at Intensively Managed Sites, for example. Future monitoring should also take place at the same time of year, namely from late-spring to early autumn. It is probably preferable to undertake SRI monitoring in Waingakia in January or early February to take advantage of warmer and clearer weather conditions.

It is recommended that professional support for data analysis be obtained for future measurements to allow for appropriate interpretation of results. This could be obtained through DOC’s technical support team.

6.0 RECOMMENDATIONS

It is recommended that:

1. Seedling Ratio Index monitoring be repeated at the six monitoring sites every three years, with the next measure occurring no later than 2027/28
2. The Raukūmara Pae Maunga Seedling Ratio Index Field Protocol be followed when measuring SRI lines
3. Consideration be given to training of project staff, especially in plant identification, practicing the RPM SRI method and use of the RPM SRI apps
4. Consideration be given to establishing SRI lines in Intensively Managed Sites, especially where ungulates may be controlled, but also to align with recommendation 3 above.
5. Decisions regarding the management of ungulates (deer) in the Raukūmara should take into account all available data for ungulate control including kill and effort data, deer abundance data, as well as outcome monitoring data
6. Advice and guidance is sought from Department of Conservation technical advisors for analysing and/or interpreting data, especially after the second measurement
7. Future monitoring should include at least two field workers who can confidently identify all the target plants
8. For future monitoring, managers should consider scheduling one monitoring site per week to ensure field workers are not overworked and to allow more flexibility for planning around weather conditions
9. Future monitoring should be undertaken at the same time of the year (late spring to early autumn) and consideration should be given to measuring the Waingakia site in mid-summer to take advantage of the warmest weather
10. Planning for future monitoring should allow for one line to be completed per day

7.0 ACKNOWLEDGEMENTS

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8.0 REFERENCES

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9.0 APPENDICES

9.1 TABLE OF SEEDLING COUNTS BY HEIGHT CLASS PER LINE WITH SEEDLING RATIO INDEX

Site	Line	Short seedlings	Tall seedlings	Seedling Ratio Index
Kahoka	KAH01	13	7	-0.30
Kahoka	KAH02	11	4	-0.47
Kahoka	KAH07	9	7	-0.13
Kahoka	KAH15	12	7	-0.26
Mangatutara	MAN02	8	2	-0.60
Mangatutara	MAN08	10	3	-0.54
Mangatutara	MAN20	13	4	-0.53
Mangatutara	MAN21	10	7	-0.18
Northern Boundary	NOR02	12	11	-0.04
Northern Boundary	NOR11	18	13	-0.16
Northern Boundary	NOR12	13	15	0.07
Northern Boundary	NOR24	16	13	-0.10
Oronui	ORO03	25	7	-0.56
Oronui	ORO06	15	16	0.03
Oronui	ORO13	14	16	0.07
Oronui	ORO19	20	14	-0.18
Raukokore	RAU01	13	6	-0.37
Raukokore	RAU09	7	3	-0.40
Raukokore	RAU16	7	2	-0.56
Raukokore	RAU24	12	2	-0.71
Waingakia	WAI06	8	4	-0.33
Waingakia	WAI07	8	1	-0.78
Waingakia	WAI21	0	0	N/A
Waingakia	WAI24	10	8	-0.11

9.2 TABLE OF AVERAGE BROWSE SCORES PER SPECIES PER SITE AND PER LINE

Entries of '0.00' represent an average score of zero, while blank entries indicate a species was not recorded at a site.

Site	ARISER	ASPBUL	BEITAW	CARSER	COPGRA	COPLUC	COPROB	COPTEF	FREBAN	FUCEXC	FUSFUS	FUSTRU	GENLIG	GRILIT	IXEBRE	MELRAM	MYRAUS	NOTFUS	NOTTRU	PODHAL	PODTOT	SCHDIG	WEIRAC	Total
Kahoka		0.00	0.00		0.00	2.50			3.00	0.00			0.50	0.00	0.00	0.29	3.00	0.00		0.00	0.00		0.00	0.22
Mangatutara	0.00	0.00	0.00	0.00	0.00	0.00		0.00			0.00		0.00		0.00	0.00				0.00		0.00	0.00	0.00
Northern Boundary		0.17	0.05	0.00	0.17	0.00		0.00	0.73				0.05			0.30				0.00		0.00	0.00	0.21
Oronui	0.00	0.00	0.00	0.00		0.00	0.00	1.00	0.78			0.00	0.00		0.00	0.25	1.00			0.00		0.00	0.00	0.09
Raukokore		0.00	0.00	0.00	0.00			0.00	0.82				0.00			0.00						0.00	0.44	0.22
Waingakia		0.00		0.00				0.00		0.00						0.00		0.25	0.00	0.00		0.00	0.00	0.04
Total	0.00	0.02	0.01	0.00	0.09	0.42	0.00	0.38	0.81	0.00	0.00	0.00	0.05	0.00	0.00	0.19	1.67	0.10	0.00	0.00	0.00	0.00	0.08	0.13